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Technical Note N-855

MAINTENANCE PAINTING OF BUILDINGS--FIRST PROGRESS REPORT

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Joseph B. Crilly and James H. Mitchell

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~~INTERNAL WORKING PAPER~~

U. S. NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California 93041

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MAINTENANCE PAINTING OF BUILDINGS--FIRST PROGRESS REPORT

Y-F020-03-03-005

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ABSTRACT

A maintenance painting work unit has been set up to find the most economical treatment, per year of protection, for repairing thick layers of paint which are cracking and flaking. The Construction Battalion Center Hospital, a wooden building, has been included in the program during a time consistent with the Public Works repainting schedule as a preliminary experiment with oil and water based paints. An oil based paint (TT-P-102a) and three water based paints (a linseed oil emulsion, a linseed oil solution, and a safflower oil emulsion) were used on the hospital. An additional water based paint (an acrylic emulsion) and TT-P-102a were used to repaint two metal Butler buildings at the Naval Civil Engineering Laboratory (NCEL). A long oil-alkyd based blister resistant paint (MIL-P-52324 (MO)) and a safflower oil-polyvinyl acetate emulsion are scheduled to be applied to other metal buildings at NCEL.

The water based paints were easier to apply and were faster drying than the oil based paints. The water based paints extended the painters working day because the water based paints are not affected by the early morning dew and the afternoon fog as the oil based paints are.

Additional buildings are scheduled to be painted at NCEL and cooperative maintenance painting experiments with other Naval activities are being attempted.

INTRODUCTION

The Naval Facilities Engineering Command is responsible for the maintenance of various types of metal and wooden structures throughout the Naval Shore Establishment. The Research Division of this Command has indicated a need for a laboratory study under field conditions. Many requests for assistance have been received from field activities which have experienced unsatisfactory performance from materials and techniques currently in use. Many older structures built during and shortly after World War II are covered with thick layers of paint which has failed by cracking and flaking. Total removal of the paint has been restricted by the cost of labor and the lack of acceptable paint removers. Paints which are now being used for repainting purposes may not always be compatible with the underlying layers of paint which can result in adhesion failures. Therefore, the problem is one of finding the most economical method, per year of protection, for repairing thick layers of paint that are cracking and flaking badly.

The objective of the maintenance painting work unit is to find repainting policies which will minimize the cost per year of protection. This will be accomplished by field testing different kinds of oil and water based paints over different levels of surface preparation.

A continuous process of routine maintenance painting by Naval Shore Installations enables NCEL to conduct field tests to the extent that the Public Works Officer and painters are willing and able to cooperate. A cooperative effort in planning, surface preparation, paint application and data collecting between Public Works and NCEL personnel is necessary for the success of this experiment. This report presents the initial phases of a maintenance painting program that have been completed through 30 June 1966.

DESIGN OF EXPERIMENT

This experiment is designed to compare the durability (blistering, chalking, cracking, flaking, peeling, etc.) of six paints, see Table I, when used over two methods of surface preparation (complete removal of old paint and, partial removal of old paint).

The data obtained on each paint system will be used to determine composition and the relationship of the paint and the level of surface preparation to the durability of the paints.

Table I. Coatings for Maintenance Painting

Topcoat	Drying Time (hr)*		Description
	ST	DH	
TT-P-102a	5	18	Paint, oil: Titanium-Lead-Zinc and oil, Exterior
MIL-P-52324 (MO)	4	18	Paint, oil, Alkyd, Exterior
NCEL No. 1	15/60	10	Linseed Oil Emulsion
NCEL No. 2	25/60	12	Linseed Oil Solution
NCEL No. 3	5/60	7	Safflower Oil Emulsion
NCEL No. 4	8/60	2	Acrylic Emulsion

Primer	Title
TT-P-25a	Primer, Paint, Exterior
TT-P-86c	Paint, Red-Lead-Base
TT-P-645	Primer, Paint, Zinc-Chromate, Alkyd Type
MIL-P-15328B	Primer, Pretreatment

* ST= set to touch, DH= dry hard: These data were obtained using a Gardner circular drying time recorder as described in Gardner and Sward "Physical and Chemical Examination of Paint, Varnish, Lacquer, and Color" 12th Ed. 1960, Gardner Laboratory, Bethesda 14, Maryland, p. 157B. The wet film thickness was 1.6 mils.

The buildings used thus far in the work unit were painted by the CBCenter Public Works painters at times consistent with the routine maintenance painting schedule set up by the Public Works Office, with paints suggested by NCEL.

Inspections of the buildings are being carried out by NCEL before, during and after repainting each surface. The data being recorded are: (1) surface condition before repainting; (2) type of surface preparation; (3) weather conditions; (4) paint application procedure; (5) total cost of job; (6) cost of material per square foot; and (7) data of importance to the program. Inspection will be carried out at six month intervals to obtain paint durability data which can be used to obtain the cost per square foot per year of protection for each different paint system.

CONSTRUCTION BATTALION CENTER HOSPITAL

The CBCenter Hospital is being used for preliminary experimentation with some of the oil and water based paints. About one-third of the surface of this large structure was painted under this program in fiscal year 1966. Public Works painters doing this work were not able to work continuously on the building, but had to spend considerable time on other assignments as required by priority scheduling in the Public Works Office. The different levels of surface preparation to be incorporated into the experimental painting of other buildings was not used here because there was not enough information available about economic factors and the effectiveness of different methods for the complete removal of old paint from wooden buildings.

The CBCenter Hospital is well suited for a painting experiment because it has many different exposures. There are seven wings on the southern part of the building each of which have south, east and west exposures. The building surface was divided into seventy-six sections, based primarily on the irregular structural design of the building. One of four different paints, designated as A, B, C, or D, was randomly chosen to be applied to each section, as shown in Figure 1.

A high degree of surface preparation was prescribed for the hospital to obtain a better than normal paint job. The condition of the old paint was bad (i.e., cracks and flakes) on the southern wings and in the patio, see Figure 2, but the northern wings of the building were generally in good condition. All loose paint was removed with a putty knife or a disk or vibrator sander and the rough edges were feathered to prevent lifting or curling of the base paint. Chalk and dirt were removed with steel wool or, if the old paint had no cracks and flakes, by water and a stiff brush. The bare wood was primed with TT-P-25a the same day it was sanded to prevent absorption of moisture overnight.

The surfaces were given two coats (by brush) of the appropriate paint chosen from: (1) TT-P-102a, a linseed oil paint; (2) Paint No. 1, a linseed oil emulsion; (3) Paint No. 2, a linseed oil solution; and (4) Paint No. 3, a safflower oil emulsion. The formulations of the paints used in this work unit are listed in the Appendix.

The old paint on the north side of the hospital seemed to be in good condition (no cracks and flakes) and some areas were washed with water to remove the chalk and dirt. On two isolated areas, blisters were noticed after the wall had been washed with water, allowed to dry for a week and then coated with TT-P-102a, a slow drying linseed oil paint. The blisters may have existed before washing with water or before painting with TT-P-102a, but they were not noticed until 24 hours after the paint was applied. Figure 3 shows adhesion failures and the flexibility of the old paint after the wall had been washed, allowed to dry for a week, and coated with TT-P-102a. The inside wall directly behind the blisters was dry but the blisters were full of water when they were noticed. Laboratory tests showed that water as well as linseed oil paint can soften the old paint which is on the hospital.

Adhesion failures also occurred when Paint No. 2, a linseed oil solution paint, was applied to a dry surface on another location of the hospital. Although adhesion failures were noticed after the slow drying linseed oil and the linseed oil solution paints were applied, these failures were localized and the full blame cannot be attributed to the slow drying oil paints.

Occasionally, gusts of wind blew sand and dirt onto a freshly painted surface. This created a problem with the slow drying paints but not with the faster drying emulsion paints such as Paint No. 1, and Paint No. 3. The set-to-touch time for Paint No. 1 is 15 minutes and Paint No. 3 is 5 minutes. The set-to-touch time for TT-P-102a is 5 hours and Paint No. 2 is 25 minutes, see Table I.

The emulsion paints were relatively fast drying, set-to-touch in 15 minutes or less, did not seem to soften the under coats of paint, were easy to apply and to clean up, and extended the painters working day. Since the water based paint is easier and faster to clean up than oil based paint the painters could work longer before starting to clean up. Water based paint is not affected by damp or foggy weather as oil based paints are, so foggy weather did not shorten the painters working day when they were painting with water base paint.

NCEL BUTLER BUILDINGS

Of Ten Butler type metal buildings selected for repainting at NCEL two have been painted on all except the north sides. Special scaffolding will be needed to paint the north sides of some of the buildings because of a steep embankment.

Loosely adherent paint on the east side of Building 563, the protective coatings laboratory, was scraped off and rusted areas were sandblasted lightly and the metal was then washed with mineral spirits. The galvanized iron was then treated with a coat of wash primer, MIL-P-15328b, followed by a coat of red lead primer, TT-P-86c, except for a ten foot strip which was primed and top coated with Paint No. 4. Tightly adherent paint on the west side of Building 563 was cleaned by brushing the surface with a detergent solution after priming when necessary with TT-P-645. The topcoat on all of the building except the ten foot strip was spray painted with two coats of TT-P-102a, class B, color. The ten foot strip was topcoated with two coats of Paint No. 4. Figure 4 illustrates the treatments for Building 563.

The paint on Building 564 was tightly adherent and was washed with a detergent solution after wire brushing the rust spots and priming as necessary with TT-P-645, see Figures 5 and 6. The topcoat on all of this building except the north side was spray painted with two coats of Paint No. 4, an acrylic emulsion. Paint No. 4 has a formulation similar to TT-P-19b but contains barium metaborate, a moldicide developed by Buckman Laboratories, Inc.,[1] as one of the pigments.

DISCUSSION

Table II shows the levels of surface preparation for the paint systems used in the program and cost data for the topcoats. Since the level of surface preparation for the buildings listed on Table II was usually spot priming only it was difficult to obtain coverage and cost data for the primers. The coverage data for the topcoats represent the coverage in square feet per gallon for a two coat system. Since it is nearly impossible to obtain a uniform thickness of paint in the field, especially by brushing, and since dry film thickness measurements are difficult to make on a wooden substrate, especially when the undercoat of paint is the same color as the topcoat, the dry film thickness values were calculated from the coverage data and total nonvolatiles in each paint.

According to the data obtained, Paint No. 2 has the best coverage and is the most economical paint to apply, assuming the same application method in all cases, see Table II. However, the Maintenance Painting work unit is still in its infancy and the cost per year of protection may well prove to favor another paint.

Adhesion failures of the old paint on the CBCenter Hospital and other wooden buildings on the CBCenter seem to be related to decaying wood and to the disintegration of an olive drab "camouflage paint" which was applied sometime during World War II. Decayed wood can usually be found adhering

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[1] H. F. Payne, Organic Coating Technology, Vol. II, John Wiley and Sons (1961) p. 1095.

Table II. Paint Application and Cost Data

Bldg	Substrate	Level of* Surface Preparation	Paint System	No. Coats	Dry Film Thickness (mil)	Application	Coverage (sq ft/gal)	Cost of Topcoat ($/gal)	Cost of Topcoat ($/100 sq ft)
90	Redwood	1	TT-P-25a/ TT-P-102a, Class A	1 2	8	Brush Brush	127	3.70	2.90
90	Redwood	1	TT-P-25a/ Paint No. 1	1 2	5	Brush Brush	132	2.90	2.20
90	Redwood	1	TT-P-25a/ Paint No. 2	1 2	5	Brush Brush	200	3.65	1.82
90	Redwood	1	TT-P-25a/ Paint No. 3	1 2	6	Brush Brush	156	3.60	2.30
563	Galvanized Steel	2	MIL-P-15328B/ TT-P-86c/ TT-P-102a, Class B	1 1 2	5	Spray Spray Spray	159	3.95+	2.47
563	Galvanized Steel	1	TT-P-645/ TT-P-102a, Class B	1 2	5	Spray Spray	159	3.95+	2.47
563	Galvanized Steel	2	Paint No. 4	2	6	Spray	125	4.95+	3.97
563	Galvanized Steel	1	Aluminum Roofing Paint	1	10	Brush	91	2.40	2.64
567	Galvanized Steel	1	Aluminum Roofing Paint	1	13	Brush	76	2.40	3.16

* Level of surface preparation: 1 - Remove loose paint, spot prime, and clean off chalk and dirt;
2 - Remove all old paint (wash if metal) and prime.

+ These prices are based on the purchase of 50 gallon batches, the others are based on 100 gallon batches.

to paint that is flaking (see Figure 7). As many as eight different layers of paint can be identified on the wooden buildings where it has not already flaked off, resulting in a paint thickness of around 20 to 30 mils.

Information obtained from the CBC Public Works personnel and others indicate that it would not be economically feasible to try to get the best levels of surface preparation by contractors. Station forces are best suited for this experiment because they usually are not trying to "beat the clock". However, even station forces did not always follow instructions and very close monitoring by NCEL personnel was necessary to attempt to get correct surface preparation and paint application data.

The CBCenter Public Works painting budget for FY67 has been reduced considerably and exterior painting work will be very limited. In order to accomplish the objectives of this work unit in a reasonable amount of time it will be necessary to set up cooperative maintenance painting programs with other military installations.

FUTURE WORK

A cooperative effort with OICC Mid Pacific, Pearl Harbor is now being considered for the repainting of a large wooden building, Building No. X-11, in Hawaii, according to a special experimental test design. NCEL personnel will inspect this building during regular trips to the Pacific test sites. Other Naval Shore Establishments will be considered as the Work Unit develops.

An experiment will be carried out with different methods of removing thick layers of paint from wood such as disk sanders, electric paint removers, and chemical paint removers, to obtain economic data and the effectiveness of the different methods.

APPENDIX

Paint Formulations Used in Experiment

Paint No. 1 White House Paint

ADM Formulary A-1008A

Lb.	Gal.		
100.0	12.00	Water	
3.0	0.15	Tetra Potassium Pyrophosphate	(1)
10.0	1.13	Nonionic Surface Active Agent	(1)
28.0	3.00	Ethylene Glycol	
6.0	0.75	Preservative	(2)
150.0	3.21	Zinc Oxide	(3)
150.0	4.29	Rutile Titanium Dioxide	(4)
50.0	1.54	Anatase Titanium Dioxide	(5)
75.0	3.15	Talc	(6)
2.0	0.25	Defoamer	(7)
120.0	14.40	2% Hydroxyethyl Cellulose Solution	(8)
15.0	1.75	Polyacrylate Thickener	(9)
230.0	28.60	AROLIN 1652	
5.0	0.52	24% Pb Drier (Water Dispersible)	(10)
2.0	0.25	6% Co Drier (Water Dispersible)	(11)
2.0	0.25	6% Mn Drier (Water Dispersible)	(12)
208.0	25.00	Water or Thickener as required	
1156.0	99.04		

30%	PVC
59%	Total Solids, Weight
44%	Total Solids, Volume
75-85 KU	Consistency
$1.65	Approximate RMC/Gallon
11.6 lb/gal	Wt/gal

(1) Tergitol NPX (Union Carbide) or equal
(2) Super-Ad-It (Nuodex) or equal
(3) No. 17 (St. Joseph) or equal
(4) TiPure R-901 (Dupont) or equal
(5) TiPure FF (DuPont) or equal
(6) Nytal 300 (Vanderbilt) or equal
(7) Colloids 581-B (Colloids, Inc) or equal
(8) Cellosize QP 4400 (Union Carbide) or equal
(9) Acrysol G-110 (Rohm & Haas) or equal
(10) 24% Lead Emulsive (Witco) or equal
(11) 6% Cobalt Emulsive (Witco) or equal
(12) 6% Manganese Emulsive (Witco) or equal

This formulation recommended by Archer Daniels Midland Co., supplier of the oil emulsion.

Paint No. 2 Exterior House Paint

(Fumeproof-self-cleaning)

(584-P-23)

Material	Pounds	Gallons
Rutile titanium dioxide	75	2.14
Anatase titanium dioxide	150	4.62
Zinc Oxide	200	4.26
Talc	150	6.31
Linaqua	355	43.50
6% cobalt naphthenate	3	0.37
6% manganese naphthenate	1	0.12
24% lead naphthenate	7.5	0.75
Kelecin 1081	12	1.50
Water	335	40.00
Total	1,288.5	103.57

Constants

PVC	32.3%
Vehicle nonvolatile	43.5%
Total nonvolatile	68.4%
Viscosity	90 - 95 KU
Grind	4 - 5 N.S.
Weight/gallon	12.5 pounds/gallon

Formulating Notes

1. For southern climates a higher ratio of rutile to anatase titanium dioxide is suggested.

2. Acicular zinc oxide is preferred to nodular zinc oxide. The nodular form appears to be more prone to wrinkling.

3. For less flow, 5 to 10 pounds of Benagel or similar agents may be added or substituted for the Kelecin 1081.

4. This is a very high gloss, "one-coat" type house paint. Lower costs may be achieved by increasing the PVC and/or replacing part of the titanium dioxide with additional talc.

This formulation recommended by Spencer Kellogg and Sons, supplier of the oil solution.

Paint No. 3 White Paint

	Pounds	Gallons
Water	185.0	22.2
Nonionic Wetting Agent	1.5	0.17
Potassium Tripolyphosphate	8.0	0.50
Tamol 731 - 25% solution	16.0	1.74
Zinc Oxide	125.0	2.66
Titanium Dioxide, Rutile	225.0	6.44
Titanium Dioxide, Anatase	50.0	1.54
Magnesium Silicate	75.0	3.16
Defoamer	1.5	0.15
Water Dispersible Fungicide	3.0	0.30
PVO 44-0	390.0	48.45
3% Solution Hydroxyethyl Cellulose	95.0	11.40
Defoamer	1.5	0.15
24% Lead Water Dispersible	9.2	0.96
6% Cobalt Water Dispersible	2.2	0.28
6% Manganese Water Dispersible	2.2	0.27
	1,190.1	100.37

Pigment Volume Concentration: 30%
Solids: 64%
Wt/gal: 11.86 lbs.
Viscosity: 70-80 K.U.

This formulation recommended by Pacific Vegetable Oil Corporation, supplier of the oil emulsion.

Paint No. 4

Exterior Tintable Acrylic Emulsion Paint

Add to mixture with agitation:		Pounds per 100 U.S. Gallons	Gallons
Water		100	12.00
Daxad 30		8	0.83
Colloid 581-B		2	0.30
Dibutyl phthalate		10	1.15
Rutile titanium dioxide		200	5.72
BUSAN 11-M1		100	3.60
325 Mesh Waterground Mica		25	1.06
Asbestine 325		68	2.86

Disperse in a high speed mill. Add the following slowly with constant stirring:

Rhoplex AC-34		512	59.10
Cellosize WP-4400	premix prior to	3	
Ethylene glycol	adding	30	3.24
Igepal Co-630		3	0.34
Water		82	9.80
		1143	100.00

Viscosity in Krebs Units, approximately	83
Pigment volume concentration in percent	35
Total solids in percent	52
Wt/gal	11.0 lbs.

Raw Material Suppliers

Daxad 30	Dewey & Almy Div. of W. R. Grace Co.
Colloid 581-B	Colloids of Carolina
BUSAN 11-M1	Buckman Laboratories, Inc.
325 Mesh Waterground Mica	English Mica Co.
Asbestine 325	International Talc Co.
Rhoplex AC-34	Rohm & Haas Co.
Cellosize WP-4400	Union Carbide Chemical Co.
Igepal CO-630	Antara Chemical Co.

This formulation recommended by Buckman Laboratories Inc., supplier of BUSAN 11-M1.

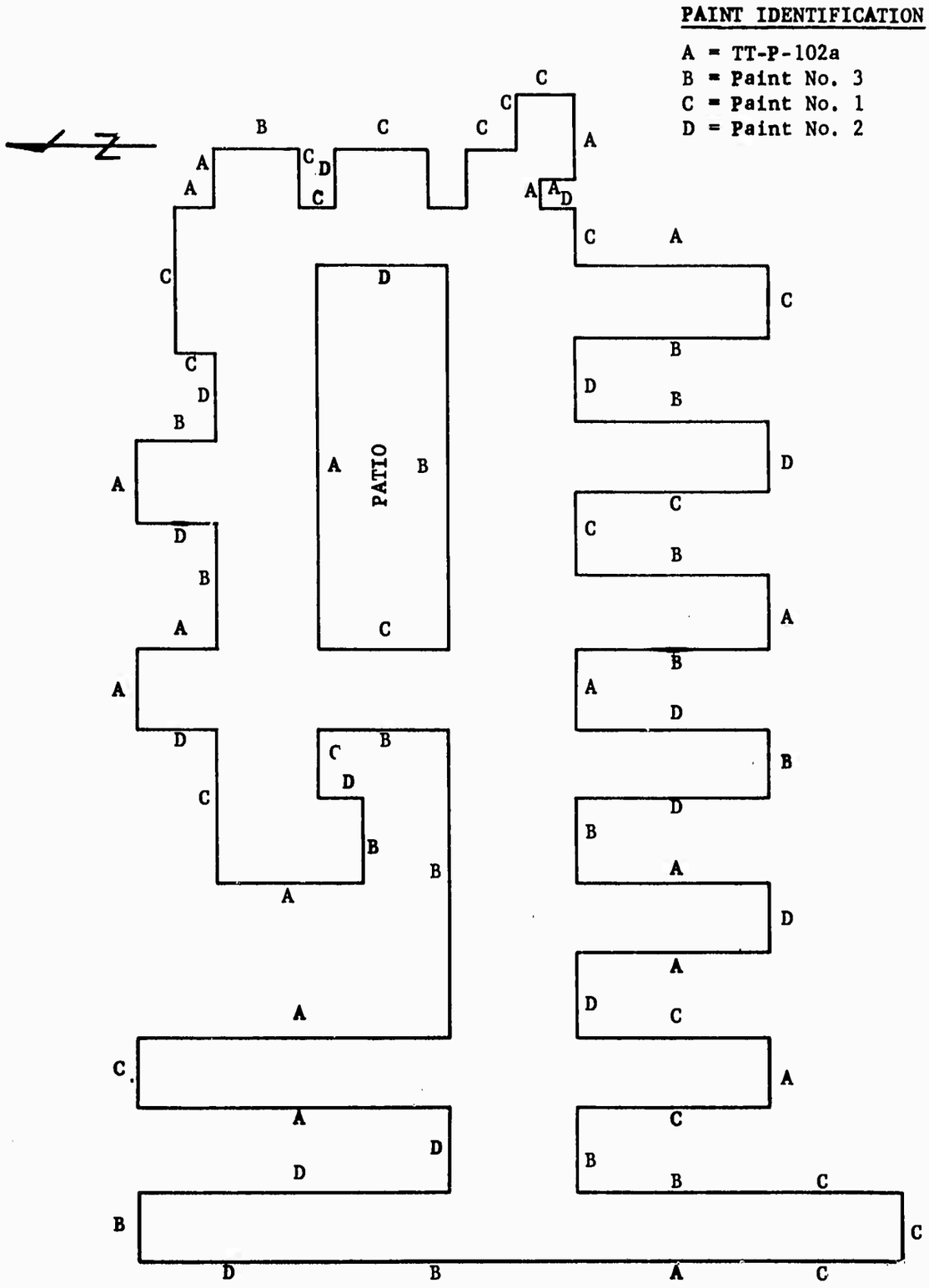

Figure 1. Drawing of CBC Base Hospital.

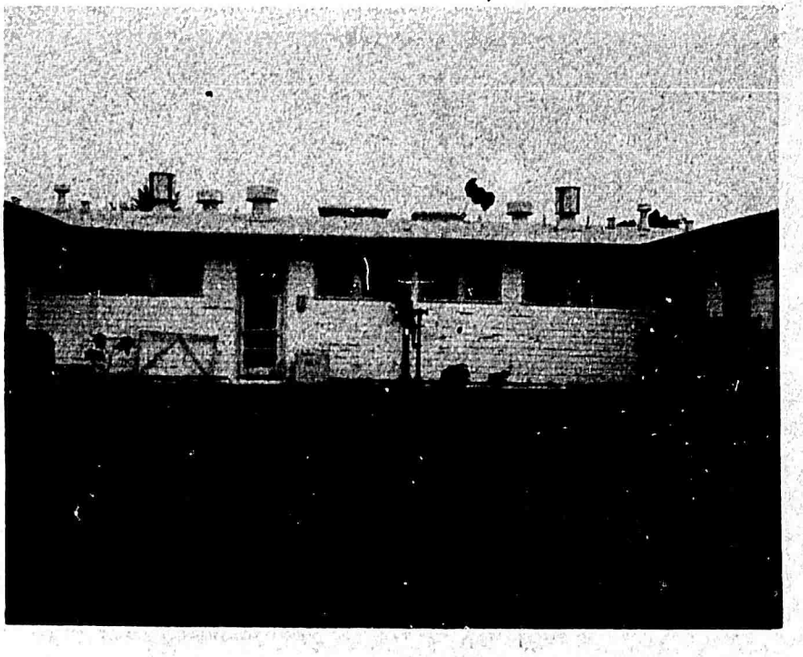

Figure 2. Condition of the old paint on a southern exposure of the Construction Battalion Center Base Hospital.

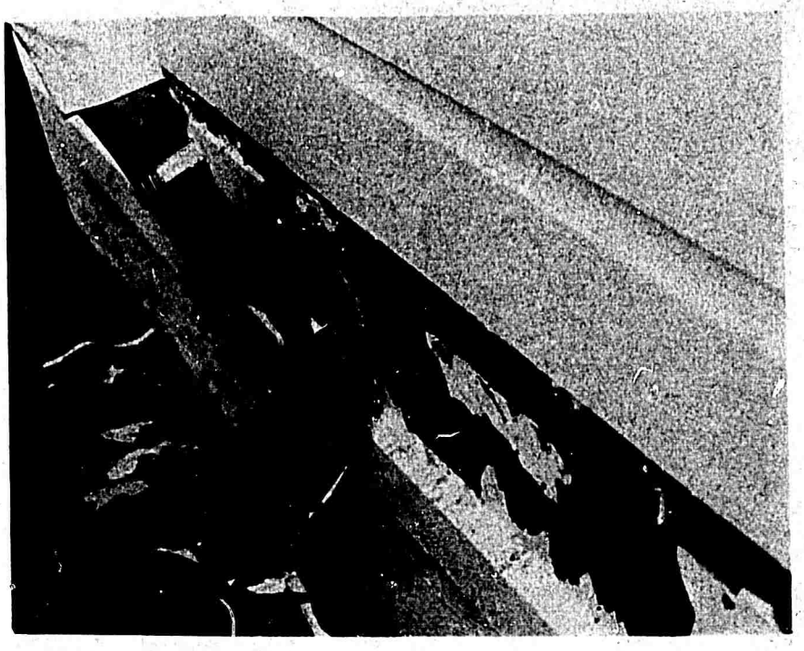

Figure 3. Adhesion failures and softening of the old paint 24 hours after washing with water and applying TT-P-102a.

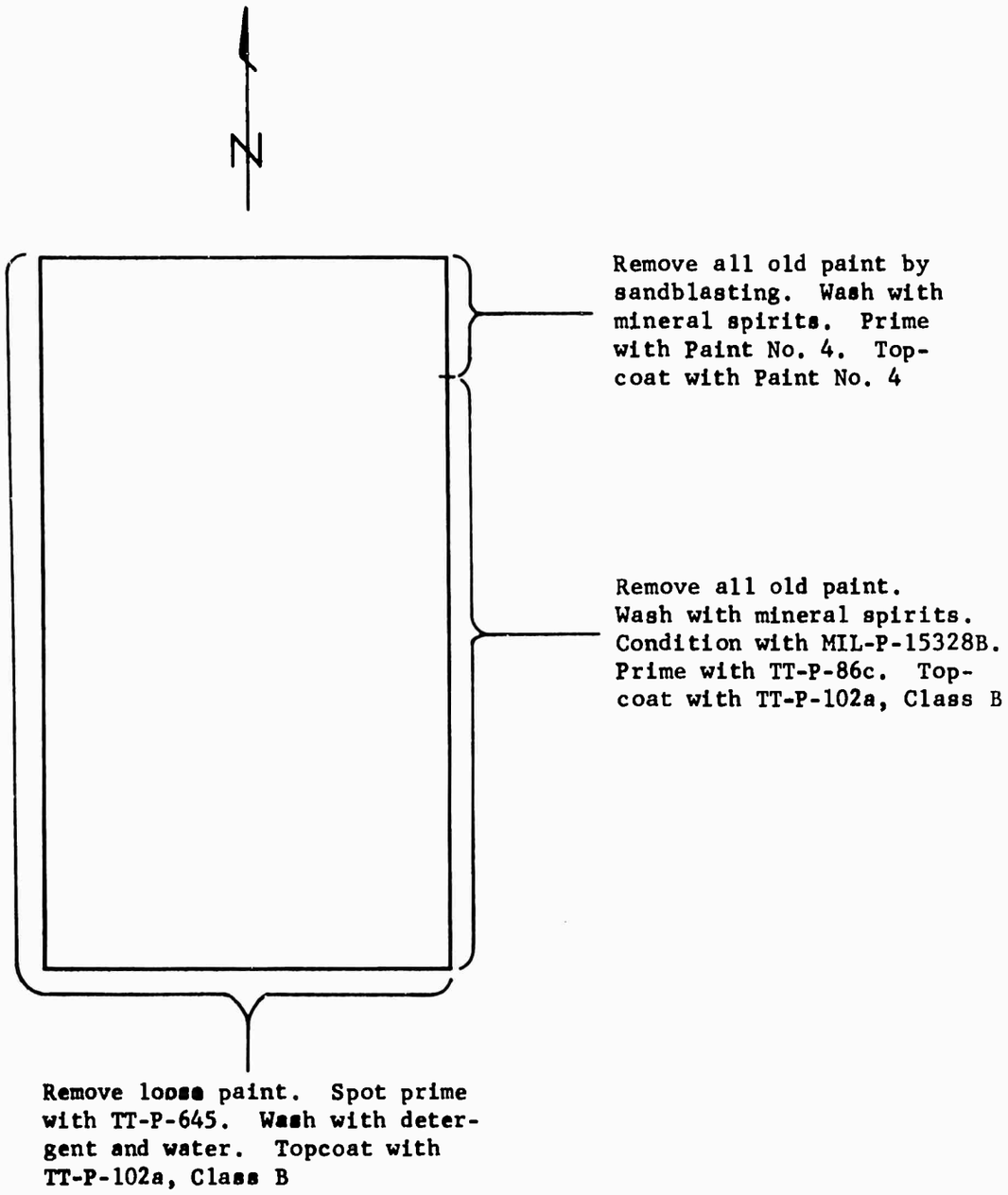

Figure 4. Repainting system for Building 563.

Figure 5. Application of detergent solution.

Figure 6. Brushing detergent solution on the surface.

Figure 7. Decayed wood adhering to paint which has flaked off a wooden building.